EFFECTS OF CONVENTIONAL TILLAGE AND NO TILLAGE ON COTTON GAS EXCHANGE AND WATER RELATIONS: STANDARD ROW VS. ULTRA-NARROW ROW SYSTEM

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Abstract

The availability of soil water to crops is considered to be the major limitation to crop production in the U.S. Use of conservation tillage systems enhances soil residue cover, water infiltration and reduces evaporative soil water loss. Our objective was to measure cotton (Gossypium hirsutum L.) leaf level photosynthesis, stomatal conductance, transpiration, and water use efficiency during reproductive growth under different row spacing and tillage conditions on a Norfolk loamy sand (Typic Kandiudults; FAO classification Luxic Ferralsols) in east-central AL. The study used a split-plot design replicated four times with row spacing (standard 40 in row and ultra-narrow row) as main plots and tillage systems (conventional and no-tillage) as subplots. These results indicate that cotton grown with standard row spacing can maintain a higher rate of photosynthesis when soil water was not limiting during the early stages of reproductive growth. At latter stages, no-tillage management may aid in conserving soil water needed during critical reproductive stages such as boll filling when demand for water is high.

Introduction

Plant growth is often reduced under soil water deficits owing to decreases in photosynthesis, stomatal aperture, and water potential (Boyer, 1982). In particular, cotton grown on loamy sand soils are highly susceptible to periods of soil water deficits due to low soil water holding capacity and little surface residue. Furthermore, periods of soil water deficits often occur during critical reproductive stages when demand for water is high. Adoption of conservation tillage systems that maintain high levels of residue cover can help mitigate such problems by enhancing soil C storage and soil water holding capacity, reducing evaporative soil water loss, and improving soil water infiltration (thereby reducing water and nutrient runoff). Other work at Auburn has shown that planting cotton with a grain drill in ultra-narrow rows (UNRC) to be a very promising cotton production system, however, little information exists on the physiological response of cotton in this production system. The objective of this study was to quantify the impact of row spacing (standard vs. ultra-narrow row) and tillage system on gas exchange and water relations of cotton during reproductive growth.

Materials and Methods

This study is a component of a larger farming systems experiment which was established on a site that had been in conventional and conservation tillage for the past 10 years (Reeves et al. 1992; Torbert et al., 1996). The cotton systems evaluated (summer of 1999) were standard row (40 in) and ultra-narrow row (8 in) under conventional and no-tillage using cereal cover crops on a Norfolk loamy sand at the E.V. Smith Research Center of the Alabama Agricultural Experiment Station in east central Alabama, USA. Cotton seeds (PayMaster 1220) were sown on 11 May 1999. The study used a split-plot design replicated four times with row spacing as main plots and tillage systems as subplots. Extension recommendations were used in managing both the soil and crop. Fertilizer application rates were based on standard soil test.

During reproductive growth, leaf level measurements (i.e., photosynthesis, stomatal conductance, transpiration, and water-use efficiency) were made twice a week using a LI-6400 Portable Photosynthesis System (LI-COR, Inc., Lincoln, NE). Measurements were taken at midday on six different randomly chosen leaves (fully expanded, sun exposed leaves at the canopy top) per plot and were initiated one week after first flower (16 July, DOY 197) and terminated on 20 August (DOY 232) ten days before defoliant application. Also during this period, soil water status was monitored at two depths (20 and 40 cm) using time domain reflectometry (data not shown). The study site had a total of 2.86 in of rainfall during the two weeks prior to study initiation. During the study period, one irrigation and six rainfall events occurred: DOY 198 (0.5 in), DOY 204 (0.05 in), DOY 206 (0.57 in), DOY 216 (0.02 in rain, 1.1 in irrigation), DOY 221 (0.06 in), and DOY 222 (0.3 in).

Statistical analyses of data were performed using the Mixed procedure of the Statistical Analysis System (SAS 1996). A significance level of $P < 0.10$ was established *a priori*.

Results and Conclusions

At the beginning of the study (DOY 197, 201, 222) the main effects of row spacing and tillage were often significant. Soil moisture conditions were optimum due to rainfall events prior to and during this period. Photosynthesis, stomatal conductance, and transpiration were higher for cotton grown

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1433-1435 (2000)
National Cotton Council, Memphis TN

in standard rows and were lower under no-tillage conditions. No differences were noted for water use efficiency.

Following this period, soil water depletion was rapid due to extensive boll development and lack of rainfall. During this time (DOY 208, 211, 215), the main effects of tillage and row spacing by tillage interactions were significant for photosynthesis, stomatal conductance, and transpiration. In general, these measures were highest in the standard row system under no-tillage, lowest in the standard row system under conventional tillage, and somewhat intermediate for the ultra-narrow system regardless of tillage system. Differences in water use efficiency were only noted on DOY 215; main effect of row spacing was significant indicating the this measure was increased only in the standard row system.

Measurements taken on DOY 217 and 222 followed irrigation/rainfall events. On DOY 217, the main effects of tillage were significant for all variables. Under no-tillage, photosynthesis, stomatal conductance, and transpiration were increased; no differences were noted on DOY 222. Differences in water use efficiency were noted on both dates; main effects of row spacing and tillage were significant indicating the this measure was increased in the standard row system and under conventional tillage.

Measurement taken on DOY 225, 230, and 232 show similar patterns as observed on DOY 217. At all dates, photosynthesis, stomatal conductance, and transpiration were increased under no-tillage. Main effects of tillage were significant on DOY 230 for water use efficiency (i.e., higher under no-tillage). On DOY 232, the main effects of row spacing was significant (i.e., water use efficiency increased in the standard row system).

These preliminary results indicate that cotton grown with standard row spacing can maintain a higher rate of photosynthesis when soil water was not limiting during the early stages of reproductive growth. At latter stages, no-tillage management may aid in conserving soil water needed during critical reproductive stages such as boll filling when demand for water is high.

Disclaimer

The use of companies, tradenames, or company names does not imply endorsement by USDA-ARS or Auburn University.

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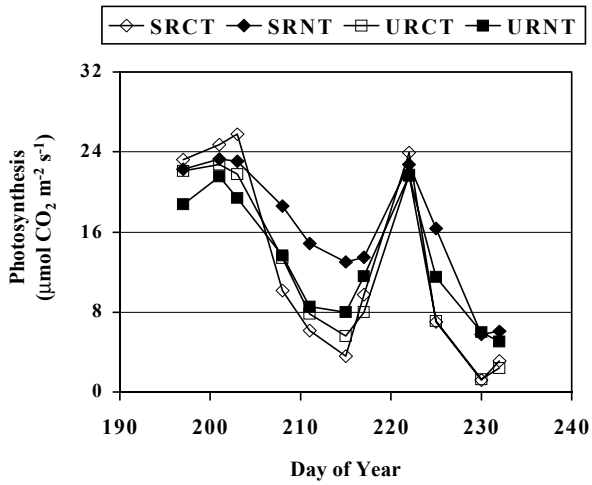

Figure 1. Photosynthesis for cotton during reproductive growth as affected by row spacing (standard row = SR; ultra-narrow row = UR) and tillage (conventional tillage = CT; no-tillage = NT).

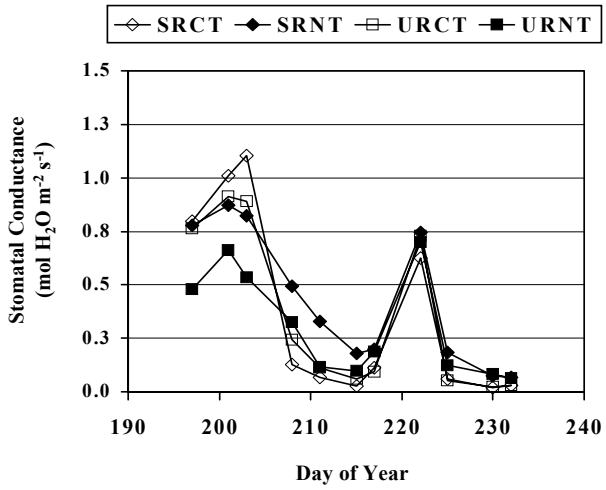

Figure 2. Stomatal conductance for cotton during reproductive growth as affected by row spacing (standard row = SR; ultra-narrow row = UR) and tillage (conventional tillage = CT; no-tillage = NT).

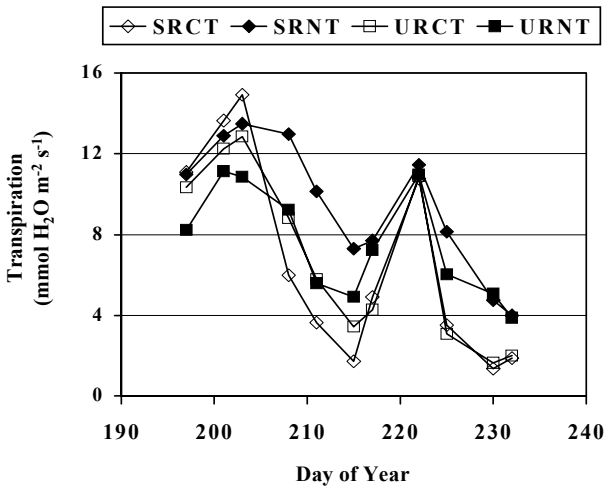

Figure 3. Transpiration for cotton during reproductive growth as affected by row spacing (standard row = SR; ultra-standard row = UR) and tillage (conventional tillage = CT; no-tillage = NT).

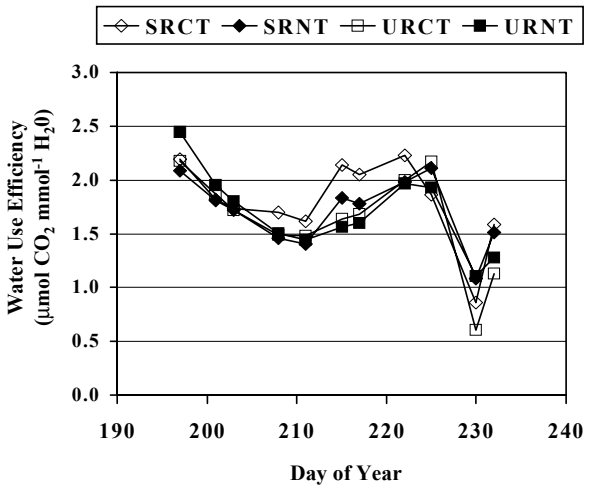

Figure 4. Water use efficiency for cotton during reproductive growth as affected by row spacing (standard row = SR; ultra-narrow row = UR) and tillage (conventional tillage = CT; no-tillage = NT).